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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, Toshiyuki Iino, a citizen of Japan residing at Kawasaki-shi, Kanagawa, Japan and Hiroaki Shirai, a citizen of Japan residing at Kawasaki-shi, Kanagawa, Japan have invented certain new and useful improvements in

AN EXCHANGE FOR CHANGING A ROUTE OF A TRANSMISSION PATH
TO BYPASS A MALFUNCTIONING SWITCH

of which the following is a specification : -

1 TITLE OF THE INVENTION

 AN EXCHANGE FOR CHANGING A ROUTE OF A
TRANSMISSION PATH TO BYPASS A MALFUNCTIONING SWITCH

5 BACKGROUND OF THE INVENTION

 1. Field of the Invention

 The present invention generally relates to
an exchange and, more particularly, to an exchange
which changes a route of a transmission path, when a
10 malfunction occurs in one of a plurality of switches,
so as to bypass the malfunctioning switch.

 In an exchange or a transmission apparatus
which communicates information including audio data
and image data, a switch network is provided with a
15 plurality of inputs and outputs so that any one of the
inputs can be connected to any one of the outputs so
as to arbitrarily change a route of a communication
path formed in the switch network.

 2. Description of the Related Art

20 A description will now be given of a
conventional method for avoiding influence of a
malfunction occurring in one of a plurality of
switches which constitute a switch network in an
exchange.

25 FIGS.1, 2 and 3 show a first, second and
third conventional exchange, respectively.

 The first conventional exchange shown in
FIG.1 comprises a working switch network 101, a spare
switch network 102 having the same structure as the
30 working switch network 101, an input switching unit
103 and an output switching unit 104. The working
switch network 101 comprises a plurality of switches,
and has a plurality of inputs and a plurality of
outputs. The input switching unit 103 and the output
35 switching unit 104 change a transmission path formed
through the exchange so that the transmission path is
formed in the spare switch network 102 instead of the

1 working switch network 101 when a malfunction occurs
in one of the switches in the working switch network
101 which is actually being used.

When a malfunction occurs in one of the
5 switches constituting the working switch network 101,
the first conventional exchange bypasses the
malfunctioning switch by switching the actually used
switch network from the working switch network 101 to
the spare switch network 102. This switching
10 operation is performed by the input switching unit 103
and the output switching unit 104. Transmission paths
formed after the switching operation are also formed
in the spare switch network 102.

The second conventional exchange shown in
15 FIG.2 comprises a switch network 111, an input
switching unit 112, an output switching unit 113 and a
header changing table circuit 114. The switch network
111 comprises a plurality of switches and a plurality
of spare switches reserved for spare use. The switch
20 network 111 has a plurality of inputs and a plurality
of outputs, and also has a plurality of spare inputs
and a plurality of spare outputs. The input switching
unit 112 and the output switching unit 113 change a
route of a transmission path formed through the
25 exchange so that the transmission path is formed
between one of the spare inputs and one of the spare
outputs when a malfunction occurs in one of the
switches included in the transmission path in the
switch network. The header changing table circuit 114
30 changes input address information, which is included
in communication information to be transmitted, to
input address information of one of the spare inputs.

When a malfunction occurs in one of the
switches in the switch network 111, the second
35 conventional exchange bypasses the malfunctioning
switch by changing a route of the transmission path
including the malfunctioning switch to a route formed

1 between one of the spare switches and one of the spare inputs.

The third conventional exchange shown in FIG.3 comprises a switch network 121 including a plurality of switches. The switch network 121 has a plurality of inputs and a plurality of outputs. When a malfunction occurs in one of the switches constituting the switch network 121, the malfunctioning switch is detected so that a transmission path routing the malfunctioning switch is changed to a transmission path routing a spare switch instead of the malfunctioning switch.

However, each of the above-mentioned conventional exchanges has the following problems.

15 In the first conventional exchange, since a detection of the malfunctioning switch in the actually used working switch network 101 is not performed, a transmission path routing the malfunctioning switch cannot be distinguished. Thus, all transmission paths including normal transmission paths must be switched to transmission paths formed in the spare switch network 102 when a malfunction occurs in one of the switches in the working switch network 101.

25 In the first, second and third conventional exchanges, since the spare switch network or the spare switch must be reserved for spare use which is not used in a normal condition, weight and size of the entire system is increased and also manufacturing cost of the exchange is increased.

30

SUMMARY OF THE INVENTION

It is a general object of the present invention to provide an exchange in which the above-mentioned problems are eliminated.

35 A more specific object of the present invention is to provide an exchange in which, when a malfunction occurs in one of a plurality of switches,

1 a transmission path bypassing the malfunctioning
switch can be formed in the absence of a spare switch
in the exchange so as to decrease weight and size of
the entire system.

5 In order to achieve the above-mentioned
objects, there is provided according to the present
invention an exchange setting a transmission path for
transmitting communication information through a
switch network comprising a plurality of switches, the
10 switch network provided with a plurality of inputs and
a plurality of outputs so that the transmission path
is formed between one of the inputs and one of the
outputs by routing the switches in the switch network,
the exchange changing a route of the transmission path
15 when a malfunction occurs in one of the switches
included in the transmission path so as to bypass the
malfunctioning switch, the exchange comprising:

a malfunctioning switch detecting unit
detecting a location of the malfunctioning switch in
20 the switch network; and

changing means for changing the route of the
transmission path by switching one of the inputs and
outputs connected to the transmission path based on
predetermined routing information so as to bypass the
25 malfunctioning switch.

According to the above-mentioned invention,
when a malfunction occurs in one of the switches
constituting the switch network, the location of the
malfunctioning switch is detected and the location
30 information is supplied to the changing means. The
location information may include an address of the
malfunctioning switch and information indicating a
position of the malfunctioning switch with respect to
the inputs and outputs of the switch network. For
35 example, if the switches in the switch network are
arranged in a matrix, the location information may
include indication of a column (stage) in which the

1 malfunctioning switch is included. When the changing
means receives the location information, the changing
means changes the route of the transmission path by
5 changing one of the inputs which is connected to the
transmission path or changing one of the outputs
connected to the transmission path. That is, the
input or the output connected to the transmission path
is changed to another input or output based on the
10 routing information which indicates a route which
bypasses the malfunctioning switch. That is, the
route of the transmission path can be changed to a
route which bypasses the malfunctioning switch by
merely changing the input or output of the switch
network.

15 Accordingly, the exchange according to the
present invention discriminate the transmission path
including the malfunctioning switch, and the route of
the transmission path is changed by changing the input
or the output of the switch network based on the
20 location of the malfunctioning switch. Thus, the
exchange according to the present invention does not
need a spare switch which is not used when the
exchange is operated in a normal condition.
Therefore, the weight and size of the entire system is
25 reduced which is advantageous for reducing
manufacturing cost.

In the exchange according to the present
invention, the changing means may comprise:

a storing unit which stores table
30 information indicating a plurality of routes each of
which bypasses one of the switches in the switch
network, each of the routes being indicated in
relation to one of the inputs and outputs of the
switch network; and

35 a selecting unit selecting one of the routes
indicated in the table information so as to change the
route of the transmission path to bypass the

1 malfunctioning switch.

Accordingly, if the location of the malfunctioning switch is detected, a route which bypasses the malfunctioning switch can be obtained
5 from the table information in relation to the input or the output of the switch network.

In one embodiment according to the present invention, the changing means may comprise:

an input switching unit switching the input
10 of the switch network;

an output switching means switching the output of the switch network; and

input and output selecting means for selecting one of the input switching unit and the
15 output switching unit so that the changing means changes the route of the transmission path by the selected one of the input switching unit and the output switching unit.

The input and output selecting means may
20 select the input switching unit when the malfunctioning switch is one of the switches directly connected to the input switching unit. Additionally, the input and output selecting means may select the output switching unit when the malfunctioning switch
25 is one of the switches directly connected to the output switching unit.

Additionally, the input and output selecting means may select the input switching unit when the malfunctioning switch is one of the switches other
30 than the switches directly connected to one of the input switching unit and the output switching unit. Alternately, the input and output selecting means selects the output switching unit when the malfunctioning switch is one of the switches other
35 than the switches directly connected to one of the input switching unit and the output switching unit.

Other objects, features and advantages of

1 the present invention will become more apparent from
the following detailed description when read in
conjunction with the accompanying drawings.

5 BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a block diagram of a first
conventional exchange;

FIG.2 is a block diagram of a second
conventional exchange;

10 FIG.3 is a block diagram of a third
conventional exchange;

FIG.4 is a block diagram of an exchange
according a first embodiment of the present invention:

FIG.5 is a block diagram of a control unit
15 shown in FIG.4;

FIG.6A is an illustration of a switch
network for explaining an operation of the control
unit when a malfunction occurs in a switch included in
a first stage; FIG.6B is an illustration for
20 explaining input table (1) information; FIG.6C is an
illustration for explaining each switch included in
the switch network shown in FIG.4;

FIG.7A is an illustration of the switch
network for explaining an operation of the control
25 unit when a malfunction occurs in a switch included in
a final stage; FIG.7B is an illustration for
explaining output table (1) information;

FIG.8A is an illustration of the switch
network for explaining an operation of the control
30 unit when a malfunction occurs in a switch included in
an intermediate stage; FIG.8B is an illustration for
explaining input table (2) information;

FIG.9A is an illustration of the switch
network for explaining an operation of the control
35 unit when a malfunction occurs in a switch included in
the intermediate stage; FIG.9B is an illustration for
explaining output table (2) information;

1 FIG.10 is a block diagram of an input
switching unit shown in FIG.4;

 FIG.11 is a block diagram of an output
switching unit shown in FIG.4;

5 FIG.12A is an illustration for explaining an
operation of an input switching unit shown in FIG.10
when a malfunction occurs in one of the switches in
the first stage; FIG.12B is an illustration for
explaining an operation of an output switching unit
10 shown in FIG.11 when a malfunction occurs in one of
the switches in the first stage;

 FIG.13A is an illustration for explaining an
operation of an input switching unit shown in FIG.10
when a malfunction occurs in one of the switches in
15 the final stage; FIG.13B is an illustration for
explaining an operation of an output switching unit
shown in FIG.11 when a malfunction occurs in one of
the switches in the final stage;

 FIG.14 is a flowchart of an operation of the
20 exchange shown in FIG.4;

 FIG.15A is an illustration for explaining a
transmission path formed in the switch network before
a change is made to the transmission path when a
malfunction occurs in one of the switches in the first
25 stage; FIG.15B is an illustration for explaining the
transmission path of FIG.15A after the change;

 FIG.16A is an illustration for explaining a
transmission path formed in the switch network before
a change is made to the transmission path when a
30 malfunction occurs in one of the switches in the final
stage; FIG.16B is an illustration for explaining the
transmission path of FIG.15A after the change;

 FIG.17A is an illustration for explaining a
transmission path formed in the switch network before
a change is made to the transmission path when a
35 malfunction occurs in one of the switches in the
intermediate stage; FIG.17B is an illustration for

1 explaining the transmission path of FIG.15A after the
change; and

FIG.18A is an illustration for explaining a
transmission path formed in the switch network before
5 a change is made to the transmission path when a
malfunction occurs in one of the switches in the first
stage; FIG.18B is an illustration for explaining the
transmission path of FIG.15A after the change.

10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description will now be given of an
exchange according to a first embodiment of the
present invention.

FIG.4 is a block diagram of the exchange
15 according to the first embodiment of the present
invention. The exchange shown in FIG.4 comprises a
switch network 1, a control unit 2, an input switching
unit 3 and an output switching unit 4. When a
malfunction occurs in one of a plurality of switches
20 in the switch network 1, the exchange switches a
transmission path so as to bypass the malfunctioning
switch.

The switch network 1 of the present
embodiment comprises twelve (12) switches each having
25 two (2) inputs and two (2) outputs so as to constitute
a switch network having eight (8) inputs and eight (8)
outputs. For example, the eight (8) inputs of the
switch network 1 are provided with eight (8) input
addresses from "000" to "111", and eight (8) outputs
30 are provided with eight (8) output addresses from
"000" to "111". In the switch network 1, the switches
are arranged in a 3x4 matrix. Four (4) switches in
the first stage (first column) are connected to the
inputs of the switch network 1. The first stage is
35 referred to as a malfunction stage (a). Four (4)
switches in the final stage (third column) are
connected to the outputs of the switch network 1. The

1 final stage is referred to as a malfunction stage (c).
Four (4) switches in the intermediate stage (second
column) are not connected with either the inputs or
the outputs. The intermediate stage is defined as a
5 malfunction stage (b). Additionally, the switches in
the first row (the uppermost row) are given a switch
address "00"; the switches in the second row are given
a switch address "01"; the switches in the third row
are given a switch address "10"; the switches in the
10 fourth row (the lowermost row) are given a switch
address "11".

The switch network 1 has a function to
change a route of a transmission path formed in the
switch network 1 based on predetermined routing
15 information of a previously set route and location
information of a malfunctioning switch. Although the
switch network 1 of the present embodiment comprises
twelve (12) switches and has eight (8) inputs and
eight (8) outputs, the number of switches, the number
20 of inputs and the number of outputs are not limited to
those numbers.

The control unit 2 serves as a changing
means for changing a route of a transmission path
formed in the switch network 1. That is, when a
25 malfunction occurs in the switch network 1, the
control unit 2 sets a final stage malfunction flag and
produces input and output unit changing information.
The final stage malfunction flag is set for selecting
one of the ways to bypass the malfunctioning switch by
30 either changing the input address or output address.
The selection by the controller is performed based on
address information of the malfunctioning switch and
information of the malfunction stage in which the
malfunction switch is included. The input and output
35 unit changing information is used for changing a
transmission path in the switch network 1 so as to
bypass the malfunctioning switch.

1 The input switching unit 3 serves as an
input switching means of the changing means. That is,
when a malfunction occurs in the switch network 1, the
input switching unit 3 switches a path to the inputs
5 of the switch network 1 based on the input and output
unit changing information produced by the control unit
2.

 The output switching unit 4 serves as an
output switching means of the changing means. That
10 is, when a malfunction occurs in the switch network 1,
the input switching unit 3 switches a path from the
outputs of the switch network 1 based on the final
stage malfunction flag set by the control unit 2.

 A description will now be given, with
15 reference to FIG.5, of the control unit 2 shown in
FIG.4 in more detail.

 As shown in FIG.5, the control unit 2
comprises a malfunctioning switch detecting unit 5, an
input and output table storing unit 6, an input table
20 (1) storing unit 7, an output table (1) storing unit
10, a selecting unit 11 and a final stage flag
producing unit 12.

 The malfunctioning switch detecting unit 5
serves as a discriminating means for discriminating a
25 switch in which a malfunction occurs. That is, when a
malfunction occurs in one of the switches in the
switch network 1, the malfunctioning switch detecting
unit 5 detects the malfunctioning switch.

 The input table (1) storing unit 7 serves as
30 a storing means for storing an input table (1)
information as predetermined routing information. The
input table (1) information is referred to when the
malfunctioning switch is included in the malfunction
stage (a) (the first stage) of the switch network 1 so
35 as to change a transmission path to bypass the
malfunctioning switch. That is, the input table (1)
storing unit 7 stores the input table (1) information

1 which indicates each switch in the switch network 1 in
relation to transmission paths each of which bypasses
each switch in the switch network 1.

5 The output table (1) storing unit 10 serves
as a storing means for storing an output table (1)
information as predetermined routing information. The
output table (1) information is referred to when the
malfunctioning switch is included in the malfunction
stage (c) (the final stage) of the switch network 1 so
10 as to change a transmission path to bypass the
malfunctioning switch. That is, the output table (1)
storing unit 10 stores the output table (1)
information which indicates each switch in the switch
network 1 in relation to transmission paths each of
15 which bypasses each switch in the switch network 1.

20 The input and output table storing unit 6,
which serves as a storing means, comprises at least
one of an input table (2) information storing unit 8
for storing an input table (2) information and an
output table (2) information storing unit 9 for
storing an output table (2) information. The input
table (2) information or the output table (2)
information is referred to when a malfunctioning
switch is included in the malfunction stage (b) (the
25 intermediate stage). The input table (2) information
and the output table (2) information serves a function
similar to the input table (1) information and the
output table (1) information.

30 The selecting unit 11 serves as a path
selecting means for selecting a transmission path
which bypasses a malfunctioning switch. That is, when
a malfunction occurs in one of the switches in the
switch network 1, the selecting unit 11 selects a
transmission path which bypasses the malfunctioning
switch based on the input table (1) information, the
35 output table (1) information, the input table (2)
information and the output table (2) information.

1 The final stage malfunction flag producing
unit 12 sends a notification to the input switching
unit 3 so as to set the final stage malfunction flag
to "ON" when switching is performed by the output
5 switching unit 4.

A description will now be given, with
reference to FIGS.6A, 6B and 6C, of an operation of
the control unit 2 when the input table (1)
information stored in the input table (1) storing unit
10 7 is referred to.

FIG.6A shows a case in which a malfunction
occurs in a switch having a switch address "00" in the
malfunction stage (a). In the case shown in FIG.6A,
an original routing information is "000111" which
15 indicates a transmission path routing from the input
having the address "000" to the output having the
address "111" (indicated by a bold solid line in
FIG.6A). Each of the switches constituting the switch
network 1 has a 0-input terminal, a 0-output terminal,
20 a 1-input terminal and a 1-output terminal as shown in
FIG.6C. The input address "000" indicates the input
terminals of the malfunction stages (a), (b) and (c),
respectively. The output address "111" indicates the
output terminals of the malfunction stages (a), (b)
25 and (c), respectively. Accordingly, communication
information input to the input address "000" of the
switch network 1 is first input to the 0-input
terminal of the switch having the switch address "00"
in the malfunction stage (a), and output from the 1-
30 output terminal of the same switch. Then, the
communication information is input to the 0-input
terminal of the switch having the switch address "01"
in the malfunction stage (b), and output from the 1-
output terminal of the same switch. Thereafter, the
35 communication information is input to the 0-input
terminal of the switch having the switch address "11"
in the malfunction stage (c), and output from the 1-

1 output terminal of the same switch. Finally, the
communication information is output from the output
address "111" of the switch network 1.

When the malfunctioning switch detecting
5 unit 5 detects the malfunctioning switch, the
selecting unit 11 refers to the input table (1)
information stored in the input table (1) storing unit
7 since the malfunctioning switch is included in the
malfunction stage (a) (the first stage). The input
10 table (1) information provides the information as
shown in FIG.6B. Accordingly, the control unit 2
refers to, as input and output information, a case in
which the input address is "000" and the switch
address "00" of the malfunctioning switch (indicated
15 by hatched portion of FIG.6B). In this case, an input
address after change indicates other than "*00". This
means that the selecting unit 11 should select input
addresses other than the input addresses "000" and
"100" so as to change a transmission path to bypass
20 the malfunctioning switch. Accordingly, for example,
the malfunctioning switch can be bypassed if the
routing information supplied to the input switching
unit 3 is changed to "001111". It should be noted
that the routing information is not limited to
25 "001111".

A description will now be given, with
reference to FIGS.7A and 7B, of an operation of the
control unit 2 when the output table (1) information
stored in the output table (1) storing unit 10 is
30 referred to.

FIG.7A shows a case in which a malfunction
occurs in a switch having a switch address "11" in the
malfunction stage (c). In the case shown in FIG.7A,
an original routing information is "000111" which
35 indicates a transmission path routing from the input
having the address "000" to the output having the
address "111" (indicated by a bold solid line in

1 FIG.7A).

When the malfunctioning switch detecting
unit 5 detects the malfunctioning switch, the
selecting unit 11 refers to the output table (1)
5 information stored in the output table (1) storing
unit 10 since the malfunctioning switch is included in
the malfunction stage (c) (the final stage). The
output table (1) information provides the information
as shown in FIG.7B. Accordingly, the control unit 2
10 refers to, as input and output information, a case in
which the output address is "111" and the switch
address "11" of the malfunctioning switch (indicated
by hatched portion of FIG.7B). In this case, an
output address after change indicates other than
15 "11*". This means that the selecting unit 11 should
select output addresses other than the output
addresses "111" and "110" so as to change a
transmission path to bypass the malfunctioning switch.
Accordingly, for example, the malfunctioning switch
20 can be bypassed if the routing information supplied to
the input switching unit 3 is changed to "000011". It
should be noted that the routing information is not
limited to "000011".

A description will now be given, with
25 reference to FIGS.8A and 8B, of an operation of the
control unit 2 when the input table (2) information
stored in the input table (2) storing unit 8 is
referred to.

FIG.8A shows a case in which a malfunction
30 occurs in a switch having a switch address "01" in the
malfunction stage (b). In the case shown in FIG.7A,
an original routing information is "000111" which
indicates a transmission path routing from the input
having the address "000" to the output having the
35 address "111" (indicated by a bold solid line in
FIG.8A).

When the malfunctioning switch detecting

1 unit 5 detects the malfunctioning switch, the
selecting unit 11 refers to the input table (2)
information stored in the input table (2) storing unit
8 since the malfunctioning switch is included in the
5 malfunction stage (b) (the intermediate stage). The
information table (2) information provides the
information as shown in FIG.8B. Accordingly, the
control unit 2 refers to, as input and output
information, a case in which the input address is
10 "000" and the switch address "01" of the
malfunctioning switch (indicated by hatched portion of
FIG.8B). In this case, an input address after change
indicates other than "**1". This means that the
selecting unit 11 should select input addresses other
15 than the input addresses "000", "010", "100" and "110"
so as to change a transmission path to bypass the
malfunctioning switch. Accordingly, for example, the
malfunctioning switch can be bypassed if the routing
information supplied to the input switching unit 3 is
20 changed to "001111". It should be noted that the
routing information is not limited to "001111".

A description will now be given, with
reference to FIGS.9A and 9B, of an operation of the
control unit 2 when the output table (2) information
25 stored in the output table (2) storing unit 9 is
referred to.

FIG.9A shows a case in which a malfunction
occurs in a switch having a switch address "01" in the
malfunction stage (c). In the case shown in FIG.9A,
30 an original routing information is "000111" which
indicates a transmission path routing from the input
having the address "000" to the output having the
address "111" (indicated by a bold solid line in
FIG.9A).

35 When the malfunctioning switch detecting
unit 5 detects the malfunctioning switch, the
selecting unit 11 refers to the output table (2)

1 information stored in the output table (2) storing
unit 9 since the malfunctioning switch is included in
the malfunction stage (b) (the intermediate stage).
The output table (2) information provides the
5 information as shown in FIG.9B. Accordingly, the
control unit 2 refers to, as input and output
information, a case in which the output address is
"111" and the switch address "01" of the
malfunctioning switch (indicated by hatched portion of
10 FIG.9B). In this case, an output address after change
indicates other than "1**". This means that the
selecting unit 11 should select output addresses other
than the output addresses "111", "110", "101" and
"100" so as to change a transmission path to bypass
15 the malfunctioning switch. Accordingly, for example,
the malfunctioning switch can be bypassed if the
routing information supplied to the input switching
unit 3 is changed to "000011". It should be noted
that the routing information is not limited to
20 "000011".

FIG.10 is a block diagram of the input
switching unit 3 shown in FIG.4. In FIG.10, the input
switching unit 3 comprises a routing information
changing unit 21, a final stage malfunction flag 22
25 and a switch 23. The input switching unit 3 changes
the routing information contained in the frame format
of the communication information, when a malfunction
occurs in the switch network 1, based on the input and
output unit changing information and the final stage
30 malfunction flag which are sent from the control unit
2.

The routing information changing unit 21
changes the contents of a frame format (header) of the
communication information, when a malfunction occurs
35 in the switch network 1, based on the input and output
unit changing information sent from the control unit
2. If the malfunctioning switch is included in the

1 first stage, the routing information changing unit 21
changes the input address. If the malfunctioning
switch is included in the final stage, the routing
information changing unit 21 changes the output
5 address. If the malfunctioning switch is included in
the intermediate stage, the routing information
changing unit 21 changes one of the input address and
the output address.

The final stage malfunction flag changing
10 unit 22 changes the status of the final stage
malfunction flag contained in the frame format of the
communication information, when a malfunction occurs
in the switch network 1, based on the final stage
malfunction flag sent from the control unit 2. When
15 the malfunctioning switch is included in the final
stage of the switch network 1 or when the
malfunctioning switch is included in the intermediate
stage of the switch network 1 and the output address
is to be changed, the final stage malfunction flag
20 changing unit 22 sets the final stage malfunction flag
to "1".

The switch 23 changes an input direction of
the communication information based on the changed
frame format of the communication information when the
25 malfunctioning switch is included in the first stage
of the switch network 1 or when the malfunctioning
switch is included in the intermediate stage and the
input address is to be changed.

FIG.11 is a block diagram of the output
30 switching unit 4 shown in FIG.4. In FIG.11, the
output switching unit 4 comprises a final stage
malfunction flag determining unit 31 and a switch 32.
The output switching unit 4 switches an outputting
direction of the communication information to be sent
35 to one of the output addresses, when a malfunction
occurs in the switch network 1, based on the input and
output unit changing information and the final stage

1 malfunction flag which are sent from the control unit
2.

The final stage malfunction flag determining
unit 31 determines the status of the final stage
5 malfunction flag contained in the frame format of the
communication information. When a result of the
determination of the final stage malfunction flag
determining unit 31 indicates "ON", the switch 32
changes the output address based on the routing
10 information contained in the frame format of the
communication information.

FIGS.12A is an illustration for explaining a
change in the frame format made by the input switching
unit 3 shown in FIG.10 when a malfunction occurs in
15 one of the switches included in the first stage as is
in the case shown in FIG.6A. FIG.12B is an
illustration for explaining a change in the frame
format made by the output switching unit 4 shown in
FIG.11 when a malfunction occurs in one of the
20 switches included in the first stage as is in the case
shown in FIG.6A. It should be noted that a change of
the frame format when the malfunctioning switch is
included in the intermediate stage and the input
address is to be changed is the same as that of the
25 case in which the malfunctioning switch is included in
the first stage of the switch network 1.

In FIG.12A, when the frame format (routing
information before change "000111", a final stage
malfunction flag "OFF") of the communication
30 information is input to the input address "000" of the
input switching unit 3, the routing information
changing unit 21 changes the routing information to,
"001111", for example, based on the input and output
unit changing information produced by the control unit
35 2 as is in the case shown in FIGS.6A and 6B. At this
time, the routing information before change is
maintained.

1 When the routing information is changed to
"001111", the input address in the frame format of the
communication information is changed from "000" to
"001" by the switch 23. The communication information
5 input to the input address "001" of the switch network
1 is output from the output address "111" of the
switch network 1.

As shown in FIG.12B, the frame format of the
communication information output from the output
10 address "111" of the switch network 1 is output to the
output address "111" of the output switching unit 4
via the final stage malfunction flag determining unit
31 and the switch 32 while the present information is
also maintained.

15 FIGS.13A is an illustration for explaining a
change in the frame format made by the input switching
unit 3 shown in FIG.10 when a malfunction occurs in
one of the switches included in the final stage as is
in the case shown in FIG.7A. FIG.13B is an
20 illustration for explaining a change in the frame
format made by the output switching unit 4 shown in
FIG.11 when a malfunction occurs in one of the
switches included in the final stage as is in the case
shown in FIG.7A. It should be noted that a change in
25 the frame format when the malfunctioning switch is
included in the intermediate stage and the output
address is to be changed is the same as that of the
case in which the malfunctioning switch is included in
the final stage of the switch network 1.

30 In FIG.13A, when the frame format (routing
information before change "000111", a final stage
malfunction flag "OFF") of the communication
information is input to the input address "000" of the
input switching unit 3, the routing information
35 changing unit 21 changes the routing information to
"000011", for example, based on the input and output
unit changing information produced by the control unit

1 2 as is in the case shown in FIGS.7A and 7B. At this
time, the routing information before change is
maintained.

When the routing information is changed to
5 "000011", the status of the final stage malfunction
flag is changed to "ON" by the final stage malfunction
flag changing unit 22. Additionally, the input
address "000" is output to the switch network 1 via
the switch 23. Thus, the communication information
10 input to the input address "000" of the switch network
1 is output from the output address "011" of the
switch network 1.

As shown in FIG.13B, the frame format of the
communication information output from the output
15 address "011" of the switch network 1 is output to the
output address "111" of the output switching unit 4
after the status of the final stage malfunction flag
is determined by the final stage malfunction flag
determining unit 31 and changed to the routing
20 information before change "111" while the present
information is also maintained.

FIG.14 is a flowchart of an operation of the
exchange according to the present embodiment when the
exchange is in a normal condition or when a
25 malfunction occurs in the switch network 1 as shown in
FIGS.15A and 15B, 16A and 16B, 17A and 17B, and 18A
and 18B. In the operation shown in FIG.14, it is
assumed that the communication information having
routing information "000111" in the frame format is
30 input, in step S1, to the input address "000" of the
input switching unit 3 when the exchange is normally
operated. The communication information is input to
the input address "000" of the switch network 1 as
shown in FIGS.15A, 16A, 17A and 18A via the routing
35 information changing unit 21, the final stage
malfunction flag changing unit 22 and the switch 23 in
the input switching unit 3.

1 Then, in step S2, a routing from the input
address "000" to the output address "111" is
performed. Each of the switches included in the
switch network 1 has the 0-input terminal, 1-input
5 terminal, 0-output terminal and the 1-output terminal
as shown in FIG.6C. Each digit of the input address
"000" corresponds to the input terminal of each of the
switches in the respective stages (a), (b) and (c).
Each digit of the output address "111" corresponds to
10 the output terminal of each of the switches in the
respective stages (a), (b) and (c). Specifically, as
shown in FIG.15A, the communication information input
to the input address "000" of the switch network 1 is
input to the 0-input terminal of the switch having the
15 switch address "00" in the stage (a), and is output
from 1-output terminal of the same switch. The
communication information is then input to the 0-input
terminal of the switch having the switch address "01"
in the stage (b), and is output from the 1-output
20 terminal of the same switch. After that, the
communication information is input to the 0-input
terminal of the switch having the switch address "11"
in the stage (c), and is output from the 1-output
terminal of the same switch. Finally, the
25 communication information is output from the output
address "111" of the switch network 1.

 The communication information output from
the switch network 1 is input to the input address
"111" of the output switching unit 4. In step S3, the
30 final stage malfunction flag determining unit 31 of
the output switching unit 4 determines whether the
final stage malfunction flag is "ON" or "OFF". In
this case, since the switch network 1 is normally
operating, it is determined that the final stage
35 malfunction flag is "OFF". Thus, the communication
information is output, in step S4, to the output
address "111" of the output switching unit 4 via the

1 switch 32.

On the other hand, when a malfunction occurs in one of the switches in the switch network 1 in step S11, the exchange according to the present embodiment
5 detects, in step S12, the location of the malfunctioning switch by the malfunctioning switch detecting unit 5.

If the switch address "00" in the stage (a) (the first stage) is detected by the malfunction
10 detecting unit 5 as the location of the malfunctioning switch, the selecting unit 11 refers to the input table (1) information stored in the input table (1) storing unit 7 in step S13. The input table (1) information provides, for example, the information
15 shown in FIG.6B, and the selecting unit 11 refers to the "input address after change" in a case in which the input address of the switch network 1 is "000" and the address of the malfunctioning switch is "00" (indicated by hatched portions in FIG.6B). Thus, the
20 selecting unit 11 selects, in step S14, a transmission path which routes from one of the input addresses other than the input addresses "000" and "100" to the output address "111" so as to bypass the malfunctioning switch. Accordingly, the selecting
25 unit 11 sends to the input switching unit 3 the input and output unit changing information which provides an instruction to change the routing information to "001111", for example. It should be noted that the routing information to be set is not limited to
30 "001111".

When the communication information having the routing information "001111" in the frame format is input to the input address "000" of the input
switching unit 3, the routing information changing
35 unit 21 of the input switching unit 3 changes the routing information to "001111", in step S15, based on the input and output unit changing information

1 produced by the selecting unit 11.

After the routing information in the frame
format of the communication information is changed to
"001111", the communication information is passed
5 through the final stage malfunction flag changing unit
22. Thereafter, the switch 23 changes, in step S16,
the input address of the switch network 1, to which
the communication information is input, from "000" to
"001". Thus, the communication information is output
10 from the switch 23 to the input address "001" of the
switch network 1.

Then, in step S2, a routing from the input
address "001" to the output address "111" is
performed. Each digit of the input address "001"
15 corresponds to the input terminal of each of the
switches in the respective stages (a), (b) and (c).
Each digit of the output address "111" corresponds to
the output terminal of each of the switches in the
respective stages (a), (b) and (c). Specifically, as
20 shown in FIG.15B, the communication information input
to the input address "001" of the switch network 1 is
input to the 0-input terminal of the switch having the
switch address "00" in the stage (a), and is output
from 1-output terminal of the same switch. The
25 communication information is then input to the 0-input
terminal of the switch having the switch address "11"
in the stage (b), and is output from the 1-output
terminal of the same switch. After that, the
communication information is input to the 0-input
30 terminal of the switch having the switch address "11"
in the stage (c), and is output from the 1-output
terminal of the same switch. Finally, the
communication information is output from the output
address "111" of the switch network 1.

35 The communication information output from
the switch network 1 is input to the input address
"111" of the output switching unit 4. In step S3, the

1 final stage malfunction flag determining unit 31 of
the output switching unit 4 determines whether the
final stage malfunction flag is "ON" or "OFF". In
this case, since the malfunctioning switch is included
5 in the first stage, it is determined that the final
stage malfunction flag is "OFF". Thus, the
communication information is output, in step S4, to
the output address "111" of the output switching unit
4 via the switch 32.

10 In the process of step S12, if the switch
address "11" in the stage (c) (the final stage) is
detected by the malfunction detecting unit 5 as the
location of the malfunctioning switch as shown in
FIG.16A, the selecting unit 11 refers to the output
15 table (1) information stored in the output table (1)
storing unit 10 in step S17. The output table (1)
information provides, for example, the information
shown in FIG.7B, and the selecting unit 11 refers to
the "output address after change" in a case in which
20 the output address of the switch network 1 is "*11"
and the address of the malfunctioning switch is "11"
(indicated by hatched portions in FIG.7B). Thus, the
selecting unit 11 selects, in step S18, a transmission
path which is connected to output addresses other than
25 the output addresses "111" and "110" so as to bypass
the malfunctioning switch. Accordingly, the selecting
unit 11 sends to the input switching unit 3 the input
and output unit changing information which instructs
to change the routing information to "001111", for
30 example. It should be noted that the routing
information to be set is not limited to "001111".

When the communication information having
the routing information "001111" in the frame format
is input to the input address "000" of the input
35 switching unit 3, the routing information changing
unit 21 of the input switching unit 3 changes the
routing information to "001111", in step S19, based on

1 the input and output unit changing information
produced by the selecting unit 11.

After the routing information in the frame
format of the communication information is changed to
5 "001111", the final stage malfunction flag changing
unit 22 changes, in step S19, the final stage
malfunction flag to "ON" and the communication
information is output to the input address "000" of
the switch network 1 via the switch 23.

10 Then, in step S2, a routing from the input
address "001" to the output address "111" is performed
in the switch network 1.

Each digit of the input address "000"
corresponds to the input terminal of each of the
15 switches in the respective stages (a), (b) and (c).
Each digit of the output address "011" corresponds to
the output terminal of each of the switches in the
respective stages (a), (b) and (c). Specifically, as
shown in FIG.16B, the communication information input
20 to the input address "000" of the switch network 1 is
input to the 0-input terminal of the switch having the
switch address "00" in the stage (a), and is output
from the 0-output terminal of the same switch. The
communication information is then input to the 0-input
25 terminal of the switch having the switch address "00"
in the stage (b), and is output from the 1-output
terminal of the same switch. After that, the
communication information is input to the 0-input
terminal of the switch having the switch address "01"
30 in the stage (c), and is output from the 1-output
terminal of the same switch. Finally, the
communication information is output from the output
address "011" of the switch network 1.

The communication information output from
35 the switch network 1 is input to the input address
"011" of the output switching unit 4. In step S3, the
final stage malfunction flag determining unit 31 of

1 the output switching unit 4 determines whether the
final stage malfunction flag is "ON" or "OFF". In
this case, since the malfunctioning switch is included
in the final stage, it is determined that the final
5 stage malfunction flag is "ON". Thus, the switch 32
changes, in step 5, the output address to which the
communication information is output to the original
output address "111", and the communication
information is output to the output address "111" of
10 the output switching unit 4 via the switch 32. Since
the switching operation of the output switching unit 4
can be performed based on the determination by the
final stage malfunction flag determining unit 31 as to
whether the final stage malfunction flag is "ON" or
15 "OFF", the output switching unit 4 can perform the
switching of the output address without a direct
instruction from the control unit 2.

In the process of step S12, if the switch
address "01" in the stage (b) (the intermediate stage)
20 is detected by the malfunction detecting unit 5 as the
location of the malfunctioning switch as shown in
FIG.17A and if an instruction is provided to change
the input address so as to bypass the malfunctioning
switch when the malfunctioning switch is located in
25 the intermediate stage of the switch network 1, the
selecting unit 11 refers to the input table (2)
information stored in the input table (2) storing unit
8 in step S20.

The input table (2) information provides,
30 for example, the information shown in FIG.8B, and the
selecting unit 11 refers to the "input address after
change" in a case in which the input address of the
switch network 1 is "000" and the address of the
malfunctioning switch is "01" (indicated by hatched
35 portions in FIG.8B). Thus, the selecting unit 11
selects, in step S22, a transmission path routing from
an input address other than the input addresses "000",

1 "010", "100" and "110" to the output address "111" so
as to bypass the malfunctioning switch. Accordingly,
the selecting unit 11 sends to the input switching
unit 3 the input and output unit changing information
5 which instructs to change the routing information to
"001111", for example. It should be noted that the
routing information to be set is not limited to
"001111".

When the communication information having
10 the routing information "001111" in the frame format
is input to the input address "000" of the input
switching unit 3, the routing information changing
unit 21 of the input switching unit 3 changes the
routing information to "001111", in step S23, based on
15 the input and output unit changing information
produced by the selecting unit 11.

After the routing information in the frame
format of the communication information is changed to
"001111", the communication information is passed
20 through the final stage malfunction flag changing unit
22. Thereafter, the final stage malfunction flag
changing unit 22 changes, in step S24, the input
address of the switch network 1, to which the
communication information is input, from "000" to
25 "001". Thus, the communication information is output
from the switch 23 to the input address "001" of the
switch network 1.

Then, in step S2, a routing from the input
address "001" to the output address "111" is performed
30 in the switch network 1.

Each digit of the input address "001"
corresponds to the input terminal of each of the
switches in the respective stages (a), (b) and (c).
Each digit of the output address "111" corresponds to
35 the output terminal of each of the switches in the
respective stages (a), (b) and (c). Specifically, as
shown in FIG.17B, the communication information input

1 to the input address "000" of the switch network 1 is
input to the 0-input terminal of the switch having the
switch address "00" in the stage (a), and is output
from 1-output terminal of the same switch. The
5 communication information is then input to the 0-input
terminal of the switch having the switch address "01"
in the stage (b), and is output from the 1-output
terminal of the same switch. After that, the
communication information is input to the 0-input
10 terminal of the switch having the switch address "11"
in the stage (c), and is output from the 1-output
terminal of the same switch. Finally, the
communication information is output from the output
address "111" of the switch network 1.

15 The communication information output from
the switch network 1 is input to the input address
"111" of the output switching unit 4. In step S3, the
final stage malfunction flag determining unit 31 of
the output switching unit 4 determines whether the
20 final stage malfunction flag is "ON" or "OFF". In
this case, since the instruction is provided so as to
change the input address when a malfunction occurs in
one of the switches in the intermediate stage, it is
determined that the final stage malfunction flag is
25 "OFF". Thus, the communication information is output,
in step S4, to the output address "111" of the output
switching unit 4 via the switch 32.

In the process of step S12, if the switch
address "11" in the stage (c) (the final stage) is
30 detected by the malfunction detecting unit 5 as the
location of the malfunctioning switch as shown in
FIG.18A and if an instruction is provided so as to
change the output address of the switch network 1 when
a malfunction occurs in one of the switches in the
35 intermediate stage, the selecting unit 11 refers to
the output table (2) information stored in the output
table (2) storing unit 9 in step S21. The output

1 table (1) information provides, for example, the
information shown in FIG.9B, and the selecting unit 11
refers to the "output address after change" in a case
in which the output address of the switch network 1 is
5 "111" and the address of the malfunctioning switch is
"01" (indicated by hatched portions in FIG.9B). Thus,
the selecting unit 11 selects, in step S22, a
transmission path which is connected to an output
address other than the output addresses "111", "110",
10 "101 and "100" so as to bypass the malfunctioning
switch. Accordingly, the selecting unit 11 sends to
the input switching unit 3 the input and output unit
changing information which provides an instruction to
change the routing information to "000011", for
15 example. It should be noted that the routing
information to be set is not limited to "000011".

When the communication information having
the routing information "000011" in the frame format
is input to the input address "000" of the input
20 switching unit 3, the routing information changing
unit 21 of the input switching unit 3 changes the
routing information to "000011", in step S23, based on
the input and output unit changing information
produced by the selecting unit 11.

25 After the routing information in the frame
format of the communication information is changed to
"000011", the final stage malfunction flag changing
unit 22 changes, in step S23, the final stage
malfunction flag to "ON" and the communication
30 information is output to the input address "000" of
the switch network 1 via the switch 23.

Then, in step S2, a routing from the input
address "000" to the output address "011" is performed
in the switch network 1.

35 Each digit of the input address "000"
corresponds to the input terminal of each of the
switches in the respective stages (a), (b) and (c).

1 Each digit of the output address "011" corresponds to
the output terminal of each of the switches in the
respective stages (a), (b) and (c). Specifically, as
shown in FIG.18B, the communication information input
5 to the input address "000" of the switch network 1 is
input to the 0-input terminal of the switch having the
switch address "00" in the stage (a), and is output
from the 0-output terminal of the same switch. The
communication information is then input to the 0-input
10 terminal of the switch having the switch address "00"
in the stage (b), and is output from the 1-output
terminal of the same switch. After that, the
communication information is input to the 0-input
terminal of the switch having the switch address "01"
15 in the stage (c), and is output from the 1-output
terminal of the same switch. Finally, the
communication information is output from the output
address "011" of the switch network 1.

The communication information output from
20 the switch network 1 is input to the input address
"011" of the output switching unit 4. In step S3, the
final stage malfunction flag determining unit 31 of
the output switching unit 4 determines whether the
final stage malfunction flag is "ON" or "OFF". In
25 this case, since the instruction is provided so as to
change the output address of the switch network 1 when
a malfunction occurs in one of the switches in the
intermediate switch, it is determined that the final
stage malfunction flag is "ON". Thus, the switch 32
30 changes, in step 5, the output address, to which the
communication information is output, to the original
output address "111", and the communication
information is output to the output address "111" of
the output switching unit 4 via the switch 32. Since
35 the switching operation of the output switching unit 4
can be performed based on the determination by the
final stage malfunction flag determining unit 31 as to

1 whether the final stage malfunction flag is "ON" or
"OFF" by the, the output switching unit 4 can perform
the switching of the output address without a direct
instruction from the control unit 2.

5 As mentioned above, according to the
exchange of the present embodiment, when a malfunction
occurs in the switch network 1 in which a transmission
path is formed to transmit the communication
information, only the transmission path including the
10 malfunctioning switch is changed so as to bypass the
malfunctioning switch. Thus, the exchange according
to the present embodiment does not have spare switches
which would cause an increase in the weight and size
of the entire system.

15 The present invention is not limited to the
specifically disclosed embodiments, and variations and
modifications may be made without departing from the
scope of the present invention.

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